Taken by Storm: Business Survival in the Aftermath of Hurricane Katrina*

Emek Basker
University of Missouri

Javier Miranda
U.S. Census Bureau

December 2013

Abstract

We use Hurricane Katrina's damage to the Mississippi coast in 2005 as a natural experiment to study business survival in the aftermath of a cost shock. We find storm damage had a "cleansing" effect on businesses: damaged establishments that returned to operation were more resilient than those that had never been damaged. This effect is particularly strong for establishments belonging to younger and smaller firms. Establishments in older and larger chains were initially less likely to exit due to storm damage, and less resilient having survived the damage. We interpret these findings as evidence that the cleansing effect of the shock is tied to the presence of financial constraints.

JEL Codes: D22, L11, L81, L83, G33, Q54

Keywords: Retail, chain, credit constraints, hurricane, Katrina, natural disaster

*Comments welcome. Author contact: emek@missouri.edu, javier.miranda@census.gov. Any opinions and conclusions expressed herein are those of the authors and do not necessarily represent the views of the U.S. Census Bureau. All results have been reviewed to ensure that no confidential information is disclosed. We thank Saku Aura, Randy Becker, Jeff Brown, Jeff Czajkowski, Steve Fazzari, Teresa Fort, Lucia Foster, Jeff Groen, Hanna Halaburda, Ron Jarmin, Shawn Klimek, Traci Mach, Erika McEntarfer, Justin Pierce, Allison Plyer, Anne Polivka, Melissa Schigoda, and seminar participants at the U.S. Census Bureau, Iowa State University, Tel-Aviv University, Dartmouth College, Boston College, Harvard Business School, the 2011 Southern Economic Association meetings (Washington DC), the 2012 NBER Universities Research Conference, the 2012 FTC Microeconomics Conference, and the 2013 NBER/CRIW Summer Institute for helpful comments and conversations. This research was started while Basker was an ASA/NSF/Census Bureau Fellow visiting the Center for Economic Studies (CES) at the U.S. Census Bureau. Basker thanks the funding agencies for their generous support and the economists at CES for their hospitality.

1 Introduction

Hurricane Katrina's landfall in the fall of 2005 famously breached levees, flooding New Orleans. It also unleashed wind gusts and storm surge that destroyed hundreds of buildings along the Mississippi gulf coast. In this paper, we study the effect of direct storm-inflicted damage on business establishments' ability to recover, focusing on the Mississippi coast. We use data from the Census Bureau's Longitudinal Business Database (LBD) on approximately 10,000 business establishments in Mississippi, including nearly 2,300 businesses in four counties with significant storm damage, combined with precise information on the location and extent of storm damage from the Federal Emergency Management Administration (FEMA). These data allow us to pinpoint which establishments were damaged or destroyed by wind or storm surge and which were left intact in the same area. We focus on establishments in the retail, restaurant, and hotel sectors, whose locations are non-fungible. Our identification comes from the randomness of actual damage within a fairly limited geographic area.

We find that the storm generated significant "excess exits" of physically damaged establishments in the short run, creating a 20–25 point wedge between the survival rate of damaged and undamaged businesses in Mississippi. This suggests that short-term distress may have caused businesses that would otherwise have survived to cease operation. In the long run, we find that businesses that weathered storm damage and returned to operation were more resilient (less likely to exit) than those left undamaged. We interpret this result as a "cleansing" or selection effect of the storm, similar to the cleansing effect of recessions suggested by Caballero and Hammour (1994, 1996).

Not all firms responded alike in the wake of either storm damage or initial survival. Short-run survival of damaged establishments was much less common for younger and smaller firms while establishments in older and larger firms were more likely to rebuilt and resume operations. *Ceteris paribus*, a doubling of the size of the chain to which an establishment belongs is associated with a 1.4 point reduction in the impact of extensive or catastrophic storm damage on the probability of exit between 2004 and 2006, and a doubling of the age

of the firm to which an establishment belongs is associated with a 3.7 point reduction in the impact of extensive or catastrophic damage on the probability of exit between 2004 and 2006. Older and larger firms have lower exit rates even in undamaged areas, but having been hit by storm damage approximately doubles the advantage that these firms have over their smaller and younger counterparts.[1]

In the years after 2006, we find that age and size remain positively correlated with survival but their effect is considerably muted among survivors of storm damage. For example, between 2006 and 2008, a doubling of the age of a firm to which an establishment belongs is associated with a 4.5-point decrease in exit probability among establishments that were not damaged in the storm, but only a 1.6-point decrease in exit probability among establishments that overcame storm damage. Put differently, relative to a control group of undamaged businesses, among heavily damaged businesses the exit rates for larger and older firms is considerably higher than that for younger and smaller businesses.

We also find that, among sole proprietors — a subset of the population dominated by small businesses —women-owned businesses experienced dramatically higher initial exit rates than male-owned businesses following physical damage, but appear somewhat more resilient than male-owned businesses in the long run. This finding corroborates the main finding and alleviates concerns that the estimated size and age effects are driven by any remaining unobserved post-Katrina demand shocks. These results also suggest the importance of considering owner demographic when examining the heterogeneity in firm response to shocks.

We interpret our results as a selection effect on two dimensions: profitability and access to credit. Establishments that survive storm damage and return to operation are both more

[1]The observation that exit rates are highest among small and young firms is not new; see, e.g., Dunne, Roberts, and Samuelson (1988); Davis, Haltiwanger, and Schuh (1996). More recently, evidence of higher exit rates for young/small business can be found in Haltiwanger, Jarmin, and Miranda (2013) and Fort, Haltiwanger, Jarmin, and Miranda (2013). Our contribution is to show how these characteristics interact with a shock to costs, using a control group of relatively unaffected businesses.

profitable than those that exit and better able to access capital and other resources required to rebuild. For large and old firms, access to capital is a less binding constraint and consequently they experience less selection based on expected future performance. At the extreme, they rebuild first, assess later. In contrast, smaller and younger firms face much more binding credit and resource constraints thus only the most profitable and productive can avoid early exit in the aftermath of a severe cost shock due to storm damage. This interpretation is consistent with evidence that policy interventions providing credit and information have a disproportionate effect on small firms (see, e.g., Jarmin, 1999; Brown and Earle, 2013). It is also consistent with evidence that shows that young and small firms are relatively financially constrained (see, e.g., Mishkin, 2008; Calomiris and Hubbard, 1990; Fazzari, Hubbard, and Petersen, 1988). Our results provide further evidence on the asymmetric response to shocks and new evidence about the selection effects and follow on dynamics.

Our paper is related to a broad literature exploring the impact of exogenous shocks on real economic activity, and to a small but growing literature on the effects of natural disasters on businesses and labor markets.

A number of papers assess how exogenous macroeconomic shocks, including monetary shocks, demand shocks, energy shocks, and technology shocks, affect the real economy. Within this literature, the papers most closely related to our examine the differential effect of these shocks on firms of different size and age. For example, Gertler and Gilchrest (1994) and Sharpe (1994) find that small firms are more sensitive to monetary and business cycle shocks, and Fort, Haltiwanger, Jarmin, and Miranda (2013), using similar data to ours, exploit geographic and time variation in business-cycle and housing-price shocks to identify the relative response of small and young firms.

A key difficulty in all these studies is disentangling cost shocks associated with business cycles, for example as a result of an increase in the cost of financing due to an increase in interest rates or the collapse of home prices, from demand shocks associated with the same cycles. Mississippi's post-Katrina experience allows us to plausibly circumvent this problem,

because damage was extremely localized, infrastructure was largely unaffected (and where infrastructure was damaged, repair times were fairly short), and there was no significant population outflow from the affected areas.[2]

Most of the disaster literature focuses on assessing the impact of natural shocks on employment and growth outcomes. Along these lines, Strobl (2011) uses county-level data to estimate the effects of hurricanes on net growth, Belasen and Polachek (2009) estimate county-level effects of hurricanes on employment and earnings, and Ewing and Kruse (2005) estimate the short- and long-term effects of hurricanes on unemployment and economic activity. In contrast, our paper uses establishment-level data to isolate the direct effect of physical storm-related damage on the establishment's survival. Closer to the spirit of our paper, Leiter, Oberhofer, and Raschky (2009) use establishment-level data on European firms to test for "creative destruction" in the aftermath of flooding. A key differences between our paper and theirs is that they have damage data only at a more aggregate level (roughly equivalent to a county), whereas we have geocoded establishment-level data on damage. This allows us to analyze heterogeneous effects of storm damage and to establish the importance of firm age and size to the impact of damage.

One recent paper that, like ours, straddles the literatures on disasters and financing is Hosono, Miyakawa, Uchino, Hazama, Ono, Uchida, and Uesugi (2012), which uses detailed firm-level data to estimate the impact of the Kobe earthquake on the supply of loans. That paper finds that firms whose headquarters were located outside the damaged area but which had borrowing relationships with banks located inside the damaged area fared worse than undamaged firms borrowing from undamaged banks. While that paper's findings underscore the importance of lending relationships to firm performance, our paper is agnostic about the mechanism by which credit favors older and larger firms. Instead, we focus on the cleansing

[2]This contrast dramatically with the situation in Louisiana, where population shifts were large, infrastructure damage was widespread, and even businesses that were not directly damaged by wind and flooding were affected by shifts in demand and disruptions to the supply chain.

effect of storm damage and on its disproportionate impact on young and small businesses.

The rest of the paper is organized as follows. Section 2 provides background information on hurricane Katrina's impact and the institutional response it generated. Section 3 describes our data in detail. Section 4 presents stylized facts from our data about the impact of storm damage to help guide our analysis. Our analysis of exits and a discussion of possible explanations is in Section 5. We discuss some implications of our findings in Section 6.

2 Katrina's Effect on the Mississippi Coast

Hurricane Katrina was the most damaging hurricane of the particularly active 2005 hurricane season. Katrina struck several locations in Florida before veering into the Gulf of Mexico and making landfall again in New Orleans on August 29, 2005 as a Category 3 hurricane. Katrina caused damage in several states, including Alabama and Florida, but the most severe damage to businesses was in Louisiana (primarily due to flooding) and along the Mississippi coast (primarily due to high winds and storm surge). Storm surges of 24–28 feet along the Mississippi coast reached as far as 12 miles inland, causing severe flooding (Knabb, Rhome, and Brown, 2005, p. 9), and the storm spawned at least 24 tornados (Federal Emergency Management Agency, 2006). In Louisiana, flood waters did not completely recede for several weeks.

Katrina's damage in Louisiana was widespread and caused large-scale population relocations and destruction of infrastructure. The population relocation created significant and persistent demand shocks; population in many of the parishes has yet to recover. In the hospitality industry, which is a major focus of our paper, infrastructure damage also reduced tourism, exacerbating the extent of the demand shock. Because it is difficult if not impossible to compare the consumption patterns of the displaced and remaining populations it is not possible to separately identify demand and cost shocks in Louisiana.

To alleviate these problems the present study focuses on Mississippi. Infrastructure damage in Mississippi was for the most part limited, localized, and short-lived, and population loss was much more limited and short-lived. Because of the localization and short life of most infrastructure damage, we minimize confounding demand and infrastructure shocks that might bias the effects of damage to specific businesses. Figure 1 shows a map of Mississippi, highlighting the four counties that were most affected by hurricane Katrina.

Given our concern with the impact demand shocks have on the relative activity of large and small firms it is important to gauge the extent of such shocks in Mississippi. A first-order measure of demand is population. Unlike in Louisiana, Mississippi's population remained largely in place in the aftermath of Katrina. Table 1 lists the 2000 and 2010 population in the affected counties and the rest of the state. Population changes between 2000 and 2010 were generally modest in Mississippi. The exception is Stone County, which saw a population gain of nearly 27%. Stone County is very small, however, and accounts for fewer than 0.5% of our observations.[3]

A second important indicator of economic recovery is the local unemployment rate, which rose in Hancock, Harrison, and Jackson counties in 2005 and 2006, but by 2007 had returned to its pre-storm levels (Sayre and Butler, 2011).

Another indicator of economic activity, especially relevant for the hospitality sectors including restaurants and hotels, is passenger air traffic. Figure 2 shows the dramatic decline and the recovery of the number of air passengers traveling to and from New Orleans and Biloxi over the period 2005–2010.[4] Passenger air travel to and from New Orleans declined by almost three log points between August and September 2005, and had only recovered to approximately 85% of its original level by the end of 2010. The initial shock was smaller at

[3]By contrast, Census data show that St. Bernard, Cameron, and Orleans parishes, the most affected parishes in Louisiana, each lost more than a a third of its population between 2000 and 2010, while other Louisiana parishes experienced large population gains due to the relocation of evacuees.

[4]The figure was calculated using monthly data from the Bureau of Transportation Statistics, available at `http://www.transtats.bts.gov/DL_SelectFields.asp?Table_ID=258`. Accessed December 12, 2013.

the Gulfport-Biloxi airport, and the recovery was complete within a few months.

The quick recovery of the Mississippi coast depended heavily on two sectors, military and casinos. Keesler Air Force Base in Biloxi, just a few blocks from the water, was heavily damaged by the storm, and at first there was some uncertainty about whether it would be rebuilt. This uncertainty was resolved within three weeks of the hurricane, when Air Force Secretary Pete Geren visited the base and promised to spend a billion dollars to fully restore it. The casinos, which had been barred from land and operated on floating barges, presented a bigger challenge, as they threatened not to rebuild unless they were allowed on land. Their threat was heeded: a month after the storm, on September 30, 2005, a controversial land-based casino bill made it through the Mississippi legislature (Smith, 2012, pp. 218-231). These two events, the Federal government's commitment to rebuilding Keesler and the casino bill, seem to have sealed the return of the Mississippi gulf coast.

Business recovery was also aided by a web of government programs that provided post-storm support to residents and business owners affected by the storms. The most substantial program directed at business owners was a loan program administered by the Small Business Administration (SBA). Access to this program was not restricted to small business and it offered lower interest rates and longer terms than conventional loans.[5] In addition, Mississippi offered small businesses in the worst-hit areas a 180-day, no-interest loan program; by the end of 2005, 392 small businesses had taken loans totaling over $9 million under this program (Kast, 2005).

Despite this and sundry other programs, the General Accounting Office (GAO) concluded that small businesses experienced credit- and funding-related difficulties recovering from the disasters. Amongst the explanations provided were the loss of financial documents,

[5]The SBA approved over 13,400 disaster loans for businesses of all sizes affected by the hurricanes from fiscal years 2005 through 2009, and more than 10,700 of these loans were identified as having assisted small businesses. 2,362 of these small business loans went to Mississippi. Most of these loans were specifically directed to small businesses that were not able to obtain credit elsewhere (Small Business Administration, 2008).

which limited their ability to apply for SBA and other loans, as well as increased costs of doing business due to insurance payments and the need to repay recovery-related debts (General Accounting Office, 2010). In other cases, business owners simply declined to take out loans even with low or no interest. Smith (2012, p. 232) documents the uneven recovery in which larger and older firms took the lead and documents that even as casinos recovered, "membership in the Gulf Coast Chapter of the Mississippi Hospitality and Restaurant Association stood at only 70 percent of its pre-Katrina strength [and] few of the mom-and-pop motels and eateries that once dotted Highway 90 had rebuilt."

3 Data

The primary building block in our analysis is the Census Bureau's Longitudinal Business Database (LBD). The LBD is a longitudinal database covering all employer establishments and firms in the U.S. non-farm private economy (for more information on the LBD, see Jarmin and Miranda, 2002). We use data from the LBD to track the activity and outcomes of all retail stores, restaurants, and hotels operating in Mississippi between 2002 and 2010. Hurricane damage is narrowly localized with some areas devastated while other in close proximity are spared the impact. We use geo-spatial damage maps from FEMA to determine which establishments were directly hit by Katrina's winds or storm surge.

We limit our analysis to retail and restaurant businesses and hotels and other accommodation facilities (including casinos) for several reasons.[6] First, they represent a very large share of the local economies in the affected counties, approximately ten times as large as manufacturing. This is important since affected areas are often small and we need sectors with enough data to conduct the analysis. Second, unlike many other service industries and some non-service industries (e.g., construction), the location of the business is non-fungible.

[6]These business establishments correspond to NAICS 44-45 and 721-722. We exclude from the analysis non-store retailers such as catalog companies and vending-machine operators, NAICS 454, as well as caterers and mobile food-service providers, NAICS 72232 and 72233.

Whereas a lawyer may continue to provide legal services and a janitorial firm may continue to provide cleaning services even if the main office is destroyed, stores, restaurants, and hotels provide their services at the business address and cannot survive otherwise. Finally, selected retail and services serve local (and tourist) demand. Demand for products in other sectors such as manufacturing may extend beyond the local area in ways that we do not observe, making it hard to determine the relative effect of demand and cost shocks for these businesses.

A few aspects about the construction of the LBD are relevant for our purpose. The LBD is constructed from several sources including administrative business payroll filings and Census collections.[7] These filings are processed by the Census Bureau on a flow basis as they are received. Establishments in the LBD are defined to be "active" if they report positive payroll to the Internal Revenue Service (IRS) for any part the year. Following Katrina, the IRS postponed tax filing deadlines several times, including waiving penalties and late fees, of individuals and businesses in affected areas. The original relief order, IRS News Release IR-2005-84, extended the filing deadlines by 45 days to taxpayers in 31 Louisiana parishes, 15 Mississippi counties, and three Alabama counties; later revisions increased the number of counties and parishes relieved and ultimately extended the deadline by another full year. Further extensions to April 2007 were also available. These filing extensions naturally cause disruptions in the flow of transactions recorded by the Census in a given year and could lead us to attribute an establishment exit when none exists. However, late filings are recorded by the Census Bureau as amendments to prior year records when they are reported by the IRS. These amendments are recorded up to two years after the original filing year. We rely on these late filings and amendments to fill in reporting gaps and to identify late filers. However, because some businesses filed even later (or perhaps not at all), we expect some reporting gaps for establishments that were otherwise active for at least part of this year, particularly

[7]Administrative records are enhanced with Census collections to identify meaningful economic units of interest such as establishments and firms.

for smaller firms. To ensure that we correctly measure exits against the true population of businesses, we use 2004 data as our baseline, and compare 2004 to 2006 for our short-run analysis, 2006 to 2008 for the medium-run analysis, and 2008 to 2010 for the long run. In each case, we limit our analysis to continuers that had existed in 2004.

We supplement the LBD with data from the integrated LBD (ILBD), which follows businesses with revenues but no payroll. The ILBD is described in some detail in Davis, Haltiwanger, Jarmin, Krizan, Miranda, Nucci, and Sandusky (2009). Non-employer businesses have firm identifiers but no establishment identifiers since an establishment is defined by the Census Bureau as the location of employment. If a firm disappears from the LBD, having laid off or lost all its employees in a given year, we search for that firm in the following year's ILBD to determine whether it continued to earn revenue. Approximately 7% of businesses that lose their employees retain a non-employer status two years later. A small number of those return to employer status in later years.

The resulting enhanced LBD is an establishment-level dataset that includes firm characteristics and includes transition events into non-employer status. An establishment in the LBD is the physical location in which business is conducted and a firm is the legal entity with operational control. Establishments that belong to the same firm are linked in the data via a firm identifier. The LBD tracks the activity of these firms over time, i.e., establishments that open or close as well as any acquisitions and divestitures of pre-existing establishments. Our data thus allows us to identify exits in the form of shutdowns (the establishment never reopens), but also exits as transitions into the non-employer universe, and exits in the form of ownership changes. In most of the analysis below, we define an establishment as a continuer from year t (the "base year") to year $t' > t$ if the establishment had positive payroll in both years or had positive payroll in year t and again in some later year $t'' > t'$, and as an exiter if it had positive payroll in year t and no payroll in year t' or thereafter. This definition of exit is conservative in that periods of temporary inactivity are not considered exit. Put differently, we identify permanent exits and exclude from the analysis transitory periods of

inactivity. The sample for our analysis of exits between 2002 and 2004 and between 2004 and 2006 includes all establishments with payroll in the base year. For the analysis of exits between 2006 and 2008 and between 2008 and 2010 we restrict the sample to establishments that had payroll in 2004 and had not exited by the relevant base year.

The firm identifier helps us determine the age and size of the entity that owns the establishment.[8] For the size of the firm, we use the number of establishments the firm operates nationwide. In the retail and hospitality context, a multi-establishment firm is usually a chain, although it can also be a firm operating, say, one retail outlet and one or more non-retail outlets (manufacturing facilities, warehouses, etc.). The firm identifier also allows us to track ownership changes.[9]

For unreported robustness checks, we have both expanded and narrowed the definition of exit in several ways. First, in some robustness checks we have expanded the definition of exit to include establishments that have changed ownership and/or establishments whose payroll fell by more than 90% between years t and t'. Conversely, we have also restricted the definition of exit to exclude the case of an establishment that ceases to report payroll but reports revenue as a non-employer in year t' or thereafter. Coefficient estimates naturally change when we redefine exit in any of these ways, but the patterns we report are robust to these changes.

In our sample approximately 18% of establishments that had payroll in 2004 are no

[8] We compute firm age using the same methodology as in Haltiwanger, Jarmin, and Miranda (2013), which is also used in the construction of the Business Dynamics Statistics (BDS); see `http://www.ces.census.gov/index.php/bds`. Firm age is defined as the age of the oldest establishment in the firm when a new firm identifier first shows up in the database. The firm then ages naturally regardless of merger and acquisition activity and as long as the firm continues to exist as such. Firm age is censored from above, because we do not know the exact age of firms that existed in 1976, the LBD's first year.

[9] One caveat is that the firm identifier changes automatically if a single-unit firm acquires a second unit or if a multi-unit firm closes or divests of all but one of its establishments. Therefore, we only code a change in the firm identifier in conjunction with a change in the multi-unit identifier as an exit if (1) the new firm identifier has already been in use for other establishments, or (2) the old firm identifier continues to be in use for other establishments. Not all ownership changes are of small businesses; for example the Las Vegas *Review-Journal* reported in March 2006 that the casino-and-hotel chain Harrah's sold one of its destroyed properties in Gulfport while reopening the other (Stutz, 2006).

longer in business in 2006; 14% of those that continue to 2006 are no longer in business by 2008; and 13% of establishments still active in 2008 are no longer in business by 2010. These exit rates increase by 1–3 percentage points when we expand the definition of exit, depending on the year and the precise definition of exit used.

We geocode establishments using Geographic Information System (GIS) tools to assign latitude and longitude based on the business's address. The Census Bureau spends considerable resources ensuring that the business address on file corresponds to the physical address. It requires businesses responding to a census or a survey form to provide the physical address of all their establishments. Establishments never covered by a census or a survey are assigned their mailing address as identified through their administrative filing forms. Beginning in 2007, the Census Bureau's Geography Division has provided geocoding for all business establishments. For establishments still in operation in 2007 we use the Geography Division's geocodes. For establishments that exited prior to 2007 we use ArcGIS's "address locator" geocoding tool to attach latitude and longitude information to business addresses. ArcGIS provides a normalized score, out of 100, to indicate the quality of the geocoding; we keep only geocodes scored 60 or above. In a small number of cases the business address may represent the address of an accountant or other hired provider who assists the business with those forms. To minimize this problem, we removed 230 businesses whose addresses were identical to addresses provided by accounting or bookkeeping firms.

Not all addresses are of the necessary quality to be able to geocode down to latitude and longitude successfully. Incomplete addresses and non-standard addresses (e.g., rural routes or PO Box addresses) are the main reasons for failures. Rural areas are known to be particularly problematic in this regard. For 2004, in each of the four Mississippi counties that experienced direct damage from Katrina — Hancock, Harrison, Jackson, and Stone Counties — we were able to geocode more than 85% of establishments. Table 3 lists the number of geo-coded establishments in each of the four affected counties in comparison with the rest of the state.

Table 2 compares summary statistics of establishment and firm characteristics for geocoded and non-geocoded establishments in the four affected counties in 2004. Geocoded establishments are, on average, six months older, but belong to firms that are about a year younger, than non-geocoded establishments. Geocoded establishments are also slightly more likely to belong to single-unit firms.[10]

Damage information comes from FEMA and is described in detail in Jarmin and Miranda (2009). Using remote-sensing technology, FEMA classified damaged areas over the period August 30 to September 10 using a four-tier damage scale: limited, moderate, extensive, and catastrophic.[11] We reduce this to a two-tier scale, combining "extensive" and "catastrophic" into one category and "limited" and "moderate" into a second category. In practice, there was very little extensive damage, with almost all of the extensive/catastrophic damage being catastrophic. Critically, damage designations are not based on insurance claims. However, because FEMA's remote-sensing maps focus primarily on developed areas, we may underestimate the damage in less-developed areas.

Following Jarmin and Miranda (2009), we add the FEMA damage information to the geocoded LBD to obtain, for each geocoded establishment, the FEMA classification of the location containing that establishment. Figure 3 shows an area on the border of Harrison and Hancock counties in Mississippi in which storm damage was widespread and highly variable. Each gray dot on the map represents a single business establishment.[12] Establishments in red (diagonally cross-hatched) areas were extensively or catastrophically damaged, while those in green (horizontal and vertical cross-hatched) areas were damaged to a limited or moderate

[10]Statistics for 2002 are available in Appendix Table A-1.

[11]FEMA's damage classification defines damage categories as follows. Limited Damage: Generally superficial damage to solid structures (e.g., loss of tiles or roof shingles); some mobile homes and light structures are damaged or displaced. Moderate Damage: Solid structures sustain exterior damage (e.g., missing roofs or roof segments); some mobile homes and light structures are destroyed, many are damaged or displaced. Extensive Damage: Some solid structures are destroyed; most sustain exterior and interior damage (roofs missing, interior walls exposed); most mobile homes and light structures are destroyed. Catastrophic Damage: Most solid and all light or mobile home structures destroyed.

[12]These dots were "jittered" in compliance with Census Bureau disclosure procedures to prevent identification of particular establishments.

degree. Establishments in the white areas were physically undamaged. In addition, a handful of business establishments were located in areas in Mississippi that still had standing water as of September 6, 2005 (one week after the storm). These areas are indicated in the figure in blue (diagonally lined) but are excluded from our analysis; none of our results are sensitive to this exclusion.

Table 3 provides summary statistics for establishments for our selected industries in the four affected counties, as well as a combined "rest of state" category, in 2004. Approximately 450 establishments were in areas later designated by FEMA as having endured extensive or catastrophic wind damage, and 470 more were in areas later designated as having suffered limited or moderate damage. We refer to all of these establishments as "damaged." The last two columns in Table 3 provide the approximate percentage of establishments in each of the designated areas. Cells representing fewer than ten observations are suppressed to comply with Census Bureau disclosure requirements.

Table 4 shows pre-storm summary statistics for the 2004 cross-sections of establishments in our data. We show the average value for establishments located in areas that were later damaged and those located in areas that were undamaged. For all the variables listed — firm size (number of establishments in firm as well as a single-unit firm indicator), firm age, establishment size (employment), and establishment age — the differences between the damaged and undamaged areas are both small and statistically insignificant.[13]

Finally, approximately 15% of our sample consists of sole proprietorships, for which additional data are available. Specifically, we are able to match sole proprietorships to their owners' demographic information from the 2000 Population Census 100% ("short-form") file. In an extension of our main results, we investigate the role of the business owner's gender on establishments' ability to survive storm damage, and on their post-storm behavior. Table 5 provides summary statistics for the sole-proprietor sample in 2004. As in the earlier

[13]Statistics for 2002 are available in Appendix Table A-2.

tables, the table shows data for undamaged and damaged establishments. We omit firm-size measures because the 99th percentile sole proprietorship in our sample operated just one establishment. Compared to the full sample of establishments, which had 15 employees on average, sole proprietorships in our sample have only approximately 4 employees. They are on average ten years old, five years younger than the average of the full sample. Approximately 30% of sole proprietorships in our sample are owned by women. No establishment- or firm-level characteristics differ statistically by damage classification within this sample.

4 Stylized Facts

In this section we provide basic facts regarding the effect of the hurricanes on the economic activity of the region to motivate the empirical analysis.

We start by taking the universe of retail, restaurant, and hotel establishments in Mississippi with positive payroll in 2004 and a geo-coded address. We partition these establishments into two subsets: those located in Hancock, Harrison, Jackson, and Stone counties (the counties in which FEMA designated damaged areas); and those located elsewhere in Mississippi. Figure 4 shows the log change in the number of restaurants, stores, and hotels that had positive payroll activity in 2004 in these two parts of the state from 2004 to 2010. The solid line, which represents the undamaged counties, trends down due to normal attrition (exit) by establishments in these sectors at roughly 9% per year. By 2010, approximately 45% of business establishments that operated in 2004 had exited. The dashed line, showing the same trend for the four counties with significant damage, follows a similar downward trend, with the exception of one year: between 2005 and 2006, the exit rate in the damaged counties exceeded that in undamaged counties by nearly 10 percentage points. The following year, exit rates for establishments that had survived to 2006 were again very similar across

the state.[14]

Next, we hone in on the four damaged counties and partition those further into areas that were designated by FEMA as undamaged, areas designated as having experienced limited or moderate damage, and areas designated as having experienced extensive or catastrophic damage. Figure 5 shows the log change in the number of continuing restaurants, stores, and hotels with positive payroll activity in each of these areas since 2004. While exit rates in the undamaged areas of the four counties are nearly indistinguishable from exit rates elsewhere in the state, this is not the case for the damaged areas of these counties. The immediate effect of Katrina was an approximately 40% reduction in the number of active establishments in the most heavily damaged areas, and a much smaller decrease in the number of establishments in the limited/moderate damage areas. Exit rates for these continuing establishments continue to diverge from 2006 to 2007, but appear to stabilize thereafter.

Having established that Katrina damage had a measurable effect on business establishment's survival, we next turn to estimating exit dynamics as a function of relevant firm characteristics.

5 Exits and Firm Characteristics

Firm heterogeneity plays an important role in theories that highlight the creative destruction process. In these models learning and selection dynamics are particularly important for young and small firms. Firms that can adjust to shocks (or are themselves the drivers of the change) survive while those that cannot adjust exit (see Syverson, 2011, for a recent review). Empirical evidence is consistent with the broad outlines of the theory and finds relatively high exit rates for young and small business (e.g. Dunne, Roberts, and Samuelson, 1989;

[14]Figure A-1 in the Appendix shows survival rates for establishments active in 2002; that figure also shows the clear break in 2005.

Davis, Haltiwanger, and Schuh, 1996; Foster, Haltiwanger, and Krizan, 2006; Haltiwanger, Jarmin, and Miranda, 2013).

Hurricane Katrina provides us with a laboratory in which to test whether smaller and younger firms are less limber in response to a specific, well-measured, and narrowly inflicted cost shock, compared with a control group that did not experience the direct cost shock but was otherwise similar, and to shed light on this learning and selection process.

5.1 Firm Age

We estimate the following cross-sectional linear probability model of exit for business establishment i located in county $j(i)$ and in six-digit NAICS $n(i)$:

$$\begin{aligned}\text{Exit}_i = \alpha_{j(i)} + \gamma_{n(i)} + \sigma \ln(\text{FirmAge})_i + \sigma_0 \mathbb{I}(\text{FirmAge}_i = 0) + \delta \text{Damage}_i \\ + \beta \ln(\text{FirmAge})_i \cdot \text{Damage}_i + \beta_0 \mathbb{I}(\text{FirmAge}_i = 0) \cdot \text{Damage}_i + \varepsilon_i, \quad (1)\end{aligned}$$

where **Exit** is a binary variable defined over a two-year horizon, e.g., from 2004 to 2006. In that case **Exit** is an indicator that equals 1 if the establishment, having had payroll in 2004, had permanently exited the employer universe by 2006. The sample includes all geo-coded Mississippi retail, restaurant, and hotel establishments with positive payroll in 2004.

On the right-hand side, $\boldsymbol{\alpha}$ is a county fixed effect intended to capture different area-wide exit probabilities due to overall demand and infrastructure shocks. As noted in Section 2, post-Katrina population relocation and infrastructure damage were much more limited in Mississippi than in Louisiana, but these events nevertheless represented demand shocks for local businesses. The county fixed effects are intended to control for these shocks. Even within these smaller areas it is likely that relocation affected some sub-populations more than others, but as long as the consumption patterns of the relocated population do not reveal a preference towards business of a specific size or age our estimates of the storm effect by business age should not be biased.

The six-digit NAICS fixed effect $\boldsymbol{\gamma}$ captures differences in exit rates across 110 types of businesses, for example due to the fact that some types of businesses, such as building-material stores, may have fared better than others in the immediate aftermath of the storm (Pearson, Hickman, and Lawrence, 2011). All variables are evaluated in the regression's base year; e.g., for exit between 2006 and 2008 we use the 2006 values for variables. **FirmAge** is measured as the age of the firm operating establishment i. Because we do not want to lose establishments belonging to new firms when we take the log of firm age, we arbitrarily set $\ln(0) = 0$ and add an indicator for establishments with age zero; the coefficient on $\mathbb{I}(\text{FirmAge} = 0)$ captures the differential exit probability of an establishment in a new entrant relative to an establishment belonging to a one-year-old firm. The firm-age variables capture different exit rates associated with firm age that might be due to productivity effects as well as differences in resources (financial and otherwise) that are available to more established firms. **Damage** is a vector of two damage indicators: limited or moderate damage and extensive or catastrophic damage. The interaction between **FirmAge** and **Damage** captures the differential exit rates for establishments in damaged areas by firm age. The error term $\boldsymbol{\varepsilon}$ is clustered at the county level. Among other things, this clustering accounts for the fact that business survival is interdependent across the county.

We include all establishments in Mississippi in the retail, restaurant, and hotel sectors as controls. However, because we have county fixed effects in all regressions, the coefficients on the two damage variables are identified within county: they represent the differential exit rates of damaged establishments relative to the average exit rate of undamaged establishments in the same county. Establishments in other counties are used to identify control variables, including the 110 NAICS fixed effects and firm and establishment characteristics. The coefficients on the interaction terms of firm age and damage are identified within county, but their magnitude is also affected by the main firm-age effects, which depend in part on the control group. We have also estimated all the regressions using alternative control groups, including only the four counties with direct damage (Hancock, Harrison, Stone, and Jack-

son), and an eight-county region that includes those four counties and four adjacent counties (Pearl River, Forrest, Perry, and George). Our estimates are not sensitive to the choice of control group.

The identifying assumption in our analysis is that, within the counties affected by Katrina, the precise path of the storm and therefore the damage inflicted was random. While businesses were clearly not damaged *due to* any underlying characteristics such as size, productivity, profitability, etc. (the hypothesis of God's wrath notwithstanding), it could still be that damage was assigned non-randomly, that is, in a way that is correlated with underlying characteristics (both observable and unobservable).[15] Table 4 in Section 3 however, provides reassurance in that observables are distributed similarly in the treated (damaged) and control (undamaged) samples. We also assume that county and detailed-industry fixed effects fully capture short-run demand shocks following the storms. The remaining differences between damaged and undamaged establishments can then be attributed to their differential recovery costs.

To further address the concern that unobserved variables may not be distributed similarly in the two samples, we also estimate all our regressions on a pre-storm period, for which we analyze exits between 2002 and 2004. Exits over this period should not have been affected by the 2005 storm, so any relationship we find between exit over this period and location in a future storm-damage zone must reflect location-specific unobserved variables that influence survival rates. These estimates therefore establish a baseline against which we can compare the post-storm regression coefficients to make causal interpretations.

Although the setting is cross-sectional and not a panel, the estimates of the impact of the storm can be interpreted as difference-in-difference estimates in the sense that we focus on the estimate of impact of the interaction of firm age and damage while controlling for the two effects separately. Comparing our estimates for the post-storm period to the pre-storm

[15] A similar issue having to do with using geographic variation to identify the impact of Wal-Mart is discussed in some detail in Basker (2006) and Basker and Noel (2009).

estimates from 2002–2004 provides an indirect third difference.

Estimates from these regressions are presented in Table 6. We estimate four regressions, each over a different two-year horizon. The first estimates the probability of exit between 2002 and 2004. This is our pre-storm baseline. The second estimates the probability of exit between 2004 and 2006 (post-storm short run). The third estimates the probability of exit between 2006 and 2008, and the last between 2008 and 2010, in both cases conditioning on the establishment having existed and having had positive payroll in 2004 (post-storm medium and long run). The first regression may be viewed as a falsification exercise, since we do not expect differential exit rates over the pre-storm period to be correlated with 2005 storm damage, except to the extent that storm damage is correlated with unobserved factors.

Column (1) reports the pre-storm results. As expected, whether because age is a signal of firm quality or because older establishments have better access to credit or other resources, establishments belonging to older firms have systematically lower exit rates; we do not find any systematic difference between the exit rates of new entrants and one-year-old firms. The only other significant coefficients the pre-storm regression are on the indicator for (future) limited/moderate damage and its interaction with firm age, indicating that establishments in areas that later experienced limited or moderate storm damage exited at rates higher than the control group, located in areas that did not experience storm damage in 2005. These excess exit rates, however, were limited to establishments in very young (zero- and one-year old) firms; for firms ages two and up, the full effect of locating in areas that later experienced limited/moderate damage, $(0.0657 - 0.1931 \cdot \ln(\mathbf{FirmAge}))$, is negative, meaning their exit probabilities are lower, not higher, than those of control-group establishments.

In column (2) we estimate the probability of exit between 2004 and 2006, the period that includes Katrina's landfall and its immediate aftermath. The main short-run effect of the storm is an increase in exit probability in areas that experienced extensive and (primarily) catastrophic damage. Establishment in these areas had a 25-percentage-point increased exit probability between 2004 and 2006. There is no statistical difference between the exit

probabilities of undamaged establishments and those that suffered limited or moderate storm damage. Firm age continues to matter: doubling an owning firm's age is associated with a four percentage point decrease in an undamaged establishment's probability of exit, as it did prior to the storm. We find however that firm age now matters even more in the damaged areas as captured by the interaction term. The same doubling of a firm's age decreases exit probability in the areas most heavily damaged by Katrina by an additional 2.6 percentage points, a two-thirds increase in the effect of age on exit. Put differently, all establishments located in damaged areas exit at higher exit rates but the exit rate differential between young and mature businesses is that much higher in damaged areas. This result is consistent with Haltiwanger, Jarmin, and Miranda (2013) finding that young firms are more sensitive to business-cycle shocks and housing-price shocks.

Why do we see this differential effect of age immediately after the storm? One possibility is that older more mature firms are more profitable; they are more productive and better managed and given the cost shock it is easier for them to absorb this unforeseen shock and thus rebuild and reopen. Alternatively, their costs of accessing financial resources and credit may be lower, allowing them to rebuild more easily. Firm age may be correlated with other factors, including access to information or attitudes towards risk, that can affect the optimal decisions of firms. Finally, young and old firms could have different incentives, leading them to make different choices with respect to rebuilding, whether due to mis-aligned incentives by managers of large firms or due to different information sets.

The next two columns provide some insight into the relative important of these alternative explanations. In the third column we estimate the probability that a business that existed in 2004 and was still in operation in 2006 will exit between 2006 and 2008.[16] In this regression we can no longer treat the coefficients as causal under the assumptions we applied

[16]Given the amount of damage experienced by firms in catastrophically affected areas we expect these firms to have had periods of inactivity during the rebuilding phase. Analysis of quarterly payroll data indicates periods of inactivity for a majority of firms in these areas immediately after the storm hit but a quick return to operations for many.

in the first two columns, because the selection criterion for inclusion in the sample is having survived to 2006. We take this selection bias into account when interpreting the coefficients.

The estimates show the direct effect of age is marginally stronger with the estimated coefficient on log age increasing (in absolute value) from -0.0559 to -0.0657.[17] We also find the direct effect of damage disappears; that is, all else equal an establishment in a damaged area and one in an undamaged area have equal exit probabilities between 2006 and 2008, conditional on having survived from 2004 to 2006. However, the interaction of age and damage is now positive. While establishments belonging to older firms are, across the board, less likely to exit, this relationship is significantly weaker in areas recovering from extensive or catastrophic storm damage. In other words, establishments belonging to older firms do not appear to have remained in operation because they are systematically better than those belonging to new entrants; rather they seem to have merely put off their exit at the cost of investing considerable sums rebuilding and repairing damaged or flattened structures. For establishments that were catastrophically damaged by the 2005 storm, age provides a very limited cushion against exit between 2006 and 2008: a doubling of a firm's age is associated with a decrease of only 1.6 percentage points in exit probability in the heavily damaged areas, compared with a 4.6 percentage-point decrease in exit probability in the undamaged parts of the same county.

This effect continues into the next period. The final column uses exits between 2008 and 2010 as the dependent variable. The sample includes establishments that survived since 2004, or had re-entered between 2004 and 2008. Now the exit rate in areas that experienced extensive or catastrophic damage years earlier is sixteen percentage points lower. In other words, conditional on surviving to 2008, businesses in damaged areas are much more resilient than those that were not tested by Katrina's winds. And while the direct effect of age is even stronger than in the other regressions, the coefficient on the interaction between age

[17] Firm age is now measured as of 2006. As all establishments are continuers at least since 2004, there is no need for the age-zero indicator in the later regressions.

and damage is larger too.

Several interesting patterns emerge from the table as a whole. While the short-run effect of Katrina was large and negative, those establishments that were damaged but returned to operation later proved more resilient than their undamaged counterparts. This effect is reminiscent of Caballero and Hammour's (1994; 1996) "cleansing" effect of recessions. Surviving the storm and rebuilding is a signal of a business's commitment, profitability, and resourcefulness. However, we find this signal is much stronger for establishments in young firms than for those belonging to older, more established, firms. The fact that exit rates in the post-storm period are relatively high for these surviving mature firms is indicative that they have become less competitive vis-à-vis the most resilient (surviving) young firms. It appears that older firms were being "cleansed" initially but to a much lesser degree.

Following a cost shock financial constraints seem to serve as a selection mechanism for young businesses. Financial institutions might consider these young business untested businesses making it harder for them to asses their risk. Only the more profitable businesses (or those that can access internal or external funds for some reason) survive while the rest do not. As businesses age and grow into larger business this selection mechanism no longer seems to play as important a role.

We have checked the robustness of these results in several unreported regressions. Changing the sample of controls to omit counties immediately adjacent to the damaged counties or even to omit all undamaged counties does not change the results in any meaningful way, although standard errors on some coefficients increase. We have also checked robustness to changes in the definition of the exit variable — redefining ownership changes as exits, assuming that establishments whose payroll has fallen by 90% or more have in fact exited, and/or recasting non-employers as continuers. We have also added establishment-level covariates such as base-year establishment age and employment to the regressions. Although coefficient magnitudes change somewhat across specifications, none of these changes has an impact on the qualitative patterns.

5.2 Firm Size

Like firm age we also expect firm size to be correlated with the firm's ability to survive a shock. We test the robustness of our age results above by replacing age with size, as follows:

$$\text{Exit}_i = \alpha_{j(i)} + \gamma_{n(i)} + \sigma \ln(\text{FirmSize})_i + \delta \text{Damage}_i + \beta \ln(\text{FirmSize})_i \cdot \text{Damage}_i + \varepsilon_i, \quad (2)$$

where **FirmSize** is measured by the number of establishments operated by the firm that owns establishment i, and range from one (for single-unit firms) to several thousand. This variable captures different exit rates associated with firm size due to the fact that larger firms have demonstrated their profitability and resourcefulness, as well as to differences in resources available to larger firms. All other variables are as defined in the previous section.

Firm size has a technical advantage over firm age, in that it is never censored and can take on any integer value. However, recent evidence suggests that firm size is a weaker indicator of a firm's ability to withstand a serious shock (Haltiwanger, Jarmin, and Miranda, 2013).

Estimates from regressions for the same four time periods as above are presented in Table 7. Across all the regressions, larger firms exit at lower probabilities. The effect of doubling a firm's size appears smaller than the effect of doubling a firm's age in Table 6, but the coefficients are not directly comparable since firm size takes values over a much larger range.

The overall pattern that emerges from these regressions is similar to that using firm age. We see both an immediate effect of extensive/catastrophic storm damage, which substantially increases exits in the short run (2004–2006), and a diminishment and eventual reversal of this effect over several years. Catastrophically damaged establishments that had survived to this point were less likely to exit between 2008 and 2010 than their undamaged counterparts, although the point estimate is smaller than the corresponding one in Table 6. In addition, while size provided a cushion against the effect of catastrophic damage in the short run, in

the long run establishments belonging to larger firms exit at a relatively higher rate. Again, the result is consistent with some "cleansing" of weaker establishments in firms with limited resources, but with a less-discriminating return to operation of establishments in firms with greater resources.

5.3 Owner Gender

The previous section showed that establishments belonging to younger and smaller firms, perhaps less resourceful firms, were much more likely to exit initially following Katrina-inflicted damage but that there was a "catch-up" effect for establishments belonging to larger and more mature firms. We have speculated that the heterogeneity in their dynamic response may be related to credit or financing constraints that are captured in the age and size variables, rather than a differential demand shock. In this section we examine this hypothesis further by focusing on the population of establishments that are organized as sole proprietorships. These businesses are uniformly small and, to the extent that a demand shock favored large businesses in the initial aftermath of the storm, these businesses would have been similarly affected.

Our sample of sole proprietorships is small, about 15% of the total number of observations we use in the age and size regressions. However, because we are able to match owner-demographics data for this subset of businesses, we are able to test whether the owner's gender is correlated with the ability of the business to weather Katrina's damage.

The literature on the relationship between owner gender and the success of a business is relatively small. Coleman and Robb (2009) find that, relative to men, women entrepreneurs start with significantly lower levels of financial capital, and that they raise less debt and equity after start up as well. This result suggests that financial constraints may hinder women-owned businesses' ability to survive storm damage. Blanchflower, Levine, and Zimmerman (2003) find evidence of limited gender-based lending discrimination. At the same time, Rosenthal and Strange (2012) find that female entrepreneurs tend to locate in different

places from male entrepreneurs and benefit less from agglomeration, and Cole and Mehran (2001) report that women-owned businesses are generally younger and smaller than their male-owned counterparts, with owners who are younger, less educated, and less experienced, which implies that women-owned businesses may be less profitable and/or less resourceful, and therefore less worth rebuilding after a major cost such as the one represented by Hurricane Katrina.[18]

To test whether female-owned sole proprietorships are disadvantaged in the recovery process relative to male-owned sole proprietorships we estimate the following cross-sectional linear probability model:

$$\text{Exit}_i = \gamma_{n(i)} + \delta \text{Damage}_i + \lambda \text{Female}_i + \mu \text{Female}_i \cdot \text{Damage}_i + \varepsilon_i \tag{3}$$

where **Female** is an indicator for a female-owned businesses, and the coefficient λ captures differential exit rates for such businesses. The coefficient μ captures the differential increase in exit probability for female-owned businesses due to severe extensive or catastrophic damage. Note that, unlike our earlier regressions, we no longer include county fixed effects due to sample size issues, although we continue to include a full set of six-digit NAICS fixed effects.

Results are shown in Table 8. Keeping in mind the limited sample we use to obtain these estimates, they are suggestive of the prevalence of credit constraints, not only differentiating small and large businesses, but even differentiating small businesses from one another. In particular, we find that small businesses owned by women were twice as likely to exit in the

[18]The literature on the relationship between race and financing and firm performance is larger and more conclusive. Historically, black entrepreneurs in the U.S. were more likely to use credit cards than other forms of finance. Chatterji and Seamans (2012) present evidence that black entrepreneurs are particularly vulnerable to limits on credit-card lending in the 1970s and 1980s, and Blanchflower, Levine, and Zimmerman (2003) show that in the 1990s, black-owned small businesses were twice as likely to be turned down for bank loans even after controlling for credit risk. More recently, Robb, Fairlie, and Robinson (2009) provide evidence from the Kauffman Firm Survey that suggests that black-owned businesses' access to capital has not improved in the 2000s. However, our sample includes very few black-owned businesses, limiting both the power of our regressions and our ability to report results without compromising Census confidentiality requirements.

immediate aftermath of the storm. While catastrophically damaged male-owned sole proprietorships continued to exit at very high rates between 2006 and 2008 relative to undamaged male-owned businesses, women-owned exits culminated early on. As in the previous sections we again find a reversal of the effect of storm damage on women-owned business by 2008 but we find the effect is not statistically significant.

5.4 Discussion

Why would more mature and larger firms rebuilt initially only to exit at a later time? We can only speculate given our data.

One possibility is that marginally profitable firms with access to the necessary resources may have seen Katrina damage as an opportunity to rebuild and improve their market position. Given the high exit rates of competitor businesses they may have seen this as an opportunity to take advantage of unmet market demand. Insofar as mature (larger) firms have more resources and easier access to credit this could explain more rebuilding by mature firms. These types of effects extend beyond size and age. If women business owners face greater credit constraints than men in similar situations, this could also explain the divergence we see in exit rates by gender in the initial aftermath of the storm.

A related but distinct possibility is that young and small businesses have different attitudes towards risk than older and larger businesses, perhaps because the sources of funding are different. Our results are consistent with the possibility that staying in business was profit maximizing in expectation but risky, due to uncertainty about the local economy's rebounding. Smith (2012, p. 229) reports that many small-business owners declined government loans at low and even zero interest, "pulled down by worry about when and how they would be able to pay it all back." Small-business owners' risk-averse behavior may be further explained by the need to provide personal property as collateral for commercial loans. Gender differences in exit patterns are consistent with this explanations, given evidence that women are more risk averse than men (see Croson and Gneezy, 2009).

The decision to rebuild and return to business may have included considerations other than the success of a particular business establishment. Particularly for large, multi-state operations, investments may not have immediate and local returns. There is some anecdotal evidence that larger firms used the Katrina rebuilding effort in their public-relations efforts. For example, a Wal-Mart press release announcing the reopening of its Waveland, Mississippi, store in August 2006 read in part: "After its building was damaged by Katrina ... the Waveland Wal-Mart quickly erected a 16,000-square foot tent on its lot to ensure people could buy food and basic items. As power across the county remained down for weeks, it was crucial for residents of this hurricane- ravaged community to replace lost items, buy food, cleaning supplies, refill prescriptions, process film and get cellular telephones connected in the storm's aftermath" (Newswires, 2006). Other large enterprises also garnered considerable media attention with their quick reopening. The return of the casino hotel "Beau Rivage" in October 2006, for example, generated considerable media attention (see, e.g., Ball, 2006).

6 Concluding Remarks

In this paper we use Hurricane Katrina as a natural experiment to examine the impact an external cost shock has on a business activity and their ability to recover. We focus in particular on business characteristics typically associated with access to credit including firm age and firm size.

We document several facts. First, establishments belonging to young and small firms were disproportionately affected by the storm. We find these firms are more vulnerable in the face of catastrophic physical damage, and they exit in large numbers following the initial shock. Second, survivors from this initial shock are more resilient than establishments that never experienced the effects of the storm. We attribute this to a cleansing effect whereby resource-constrained and less-productive businesses exit early. Third, we find that young and small businesses that survive are particularly resilient in this regard and exit at relatively low

rates compared to mature and larger business. Finally, we find that the asymmetry of this cleansing effect with regards to the firm age and size continues to affect market dynamics many years after the initial shock. Among affected businesses, relative exit rates for more mature and larger businesses continue to exceed normal levels a full five years after the initial shock. The converse is true for the youngest and smallest businesses, whose exit rates are suppressed relative to their undamaged counterparts.

We supplement these results with estimates of the effect of storm damage on sole proprietors, a population of businesses that are uniformly small, so any size-specific demand shock would have hit these businesses uniformly. Within this set of businesses, we find that having experienced extensive or catastrophic storm damage had twice the effect on women-owned businesses as on male-owned businesses in the short run. In the long run, women-owned businesses were somewhat more resilient than their male-owned counterparts.

These results are consistent with established evidence of a wedge between the cost of internal and the cost of external credit, suggesting that older and larger firms are less credit constrained than smaller and younger ones or face smaller cost of financing. At the same time, the fact that many of these large/mature firms eventually also exit pose questions as to their management, their motivation in choosing to rebuild, and ultimately the wisdom of these investments.

Across the board, our results suggest that financial constraints serve as a selection mechanism for young, small and female owned business following a cost shock. We are agnostic as to the particular mechanism at work. Whether it is due to difficulties accessing credit from financial institutions or risk aversion on the part of business owners with limited personal resources, our results suggest that only the more profitable of these businesses survive the initial shock. As businesses age and grow, this selection mechanism seems to diminish in importance so that in the face of an unexpected cost shock survival of older/larger businesses profitability seems to play less of a role. But young and small businesses that face a major cost shock early in their development cannot reach this later phase.

The amount of "cleansing" brought about by a cost shock in the face of financial constraints may or may not be optimal. It may be that the cost shock merely accelerated exits of businesses that would have exited eventually. But if small, young, and women-owned businesses are constrained in their ability to borrow or risk averse with regard to incurring debt, these cost shocks could have also shut down viable businesses that could otherwise have survived. The fact that the asymmetry continues to affect market dynamics many years after the initial shock suggests this may in fact be the case. Well beyond the effect of Hurricane Katrina, our findings imply that asymmetric effects of other types of shocks, including business-cycle shocks, may linger for many years.

References

Ball, M. (2006) "The comeback Coast," *New Orleans Time-Picayune*, October 9.

Basker, E. (2006) "When Good Instruments Go Bad: A Reply to Neumark, Zhang, and Ciccarella," unpublished paper, University of Missouri.

Basker, E., and M. Noel (2009) "The Evolving Food Chain: Competitive Effects of Wal-Mart's Entry into the Supermarket Industry," *Journal of Economics and Management Strategy*, 18(4), 977–1009.

Belasen, A. R., and S. W. Polachek (2009) "How Disasters Affect Local Labor Markets: The Effects of Hurricanes in Florida," *Journal of Human Resources*, 44(1), 251–276.

Blanchflower, D. G., P. B. Levine, and D. J. Zimmerman (2003) "Discrimination in the Small Business Credit Market," *Review of Economics and Statistics*, 85(4), 930–943.

Brown, D., and J. Earle (2013) "Do SBA Loans Create Jobs?," IZA Discussion Paper 7544.

Caballero, R. J., and M. L. Hammour (1994) "The Cleansing Effect of Recessions," *American Economic Review*, 84(5), 1350–1368.

——— (1996) "On the Timing and Efficiency of Creative Destruction," *Quarterly Journal of Economics*, 111(3), 805–852.

Calomiris, C., and G. Hubbard (1990) "Firm Heterogeneity, Internal Finance and Credit Rationing," *Economic Journal*, 100(399), 90–104.

Chatterji, A. K., and R. C. Seamans (2012) "Entrepreneurial Finance, Credit Cards and Race," *Journal of Financial Economics*, 106(1), 182–195.

Cole, R. A., and H. Mehran (2001) "Gender and the Availability of Credit to Privately Held Firms: Evidence from the Surveys of Small Business Finances," unpublished paper, DePaul University and Federal Reserve Bank of New York.

Coleman, S., and A. Robb (2009) "A Comparison of New Firm Financing by Gender: Evidence from the Kauffman Firm Survey Data," *Small Business Economics*, 33, 397–411.

Croson, R., and U. Gneezy (2009) "Gender Differences in Preferences," *Journal of Economic Literature*, 47(2), 448–474.

Davis, S., J. Haltiwanger, and S. Schuh (1996) *Job Creation and Destruction*. MIT Press, Cambridge, MA.

Davis, S. J., J. Haltiwanger, R. S. Jarmin, C. Krizan, J. Miranda, A. Nucci, and K. Sandusky (2009) "Measuring the Dynamics of Young and Small Businesses: Integrating the Employer and Nonemployer Universes," in *Producer Dynamics: New Evidence from Micro Data*, ed. by J. B. Jensen, T. Dunne, and M. J. Roberts. University of Chicago Press.

Dunne, T., M. J. Roberts, and L. Samuelson (1988) "Patterns of Firm Entry and Exit in U.S. Manufacturing Industries," *RAND Journal of Economics*, 19(4), 495–515.

——— (1989) "Plant Turnover and Gross Employment Flows in the U.S. manufacturing Sector," *Journal of Labor Economics*, 7(1), 48–71.

Ewing, B. T., and J. B. Kruse (2005) "Hurricanes and Unemployment," unpublished paper, East Carolina University Center for Natural Hazards Research.

Fazzari, S. M., R. G. Hubbard, and B. C. Petersen (1988) "Financing Constraints and Corporate Investment," *Brookings Papers on Economic Activity*, 1988(1), 141–206.

Federal Emergency Management Agency (2006) "Summary Report on Building Performance: Hurricane Katrina 2005," Discussion Paper 548, FEMA.

Fort, T., J. Haltiwanger, R. Jarmin, and J. Miranda (2013) "How Firms Respond to Business Cycles: The Role of Firm Age and Firm Size," *IMF Economic Review*, 61(3), 520–559.

Foster, L., J. Haltiwanger, and C. J. Krizan (2006) "Market Selection, Reallocation and Restructuring in the U.S. Retail Trade Sector in the 1990s," *Review of Economics and Statistics*, 88(4), 748–758.

General Accounting Office (2010) "Hurricanes Katrina and Rita," Discussion Paper GAO-10-723, GAO.

Gertler, M., and S. Gilchrest (1994) "Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms," *Quarterly Journal of Economics*, 109(2), 309–340.

Haltiwanger, J., R. Jarmin, and J. Miranda (2013) "Who Creates Jobs? Small vs. Large vs. Young," *Review of Economics and Statistics*, 95(2), 347–361.

Hosono, K., D. Miyakawa, T. Uchino, M. Hazama, A. Ono, H. Uchida, and I. Uesugi (2012) "Natural Disasters, Bank Lending, and Firm Investment," Research Institute of Economy, Trade, and Industry (RIETI) Discussion Paper 12-E-062.

Jarmin, R. S. (1999) "Government Technical Assistance Programs and Plant Survival: The Role of Plant Ownership Type," unpublished paper, U.S. Census Bureau.

Jarmin, R. S., and J. Miranda (2002) "The Longitudinal Business Database," unpublished paper, U.S. Census Bureau.

——— (2009) "The Impact of Hurricanes Katrina, Rita and Wilma on Business Establishments," *Jounral of Business Valuation and Economic Loss Analysis*, 4(2), article 7.

Kast, S. (2005) "Disaster Bridge Loan Deadline Extended to Jan. 31 for Southernmost Counties," *US Fed News*.

Knabb, R. D., J. R. Rhome, and D. P. Brown (2005) "Tropical Cyclone Report: Hurricane Katrina," Discussion Paper AL122005, National Hurricane Center.

Leiter, A. M., H. Oberhofer, and P. A. Raschky (2009) "Creative Disasters? Flooding Effects on Capital, Labour and Productivity within European Firms," *Environmental and Resource Economics*, 43(3), 333–350.

Mishkin, F. (2008) "Small Business Lending," Testimony before the Committee on Small Business and Entrepreneurship, U.S. Senate.

Newswires, P. (2006) "Wal-Mart Supercenter Returns to Waveland With Gulf Coast Community Celebration," *PR Newswires*, August 3.

Pearson, M. M., T. M. Hickman, and K. E. Lawrence (2011) "Retail Recovery from Natural Disasters: New Orleans versus Eight Other US Disaster Sites," *International Review of Retail, Distribution and Consumer Research*, 21(5), 415–444.

Robb, A. M., R. W. Fairlie, and D. T. Robinson (2009) "Financial Capital Injections among New Black and White Business Ventures: Evidence from the Kauffman Firm Survey," unpublished paper, University of California, Santa Cruz and Duke University.

Rosenthal, S. S., and W. C. Strange (2012) "Female Entrepreneurship, Agglomeration, and a New Spatial Mismatch," *Review of Economics and Statistics*, 94(3), 764–788.

Sayre, E. A., and D. Butler (2011) "The Geography of Recovery: An Analysis of the Mississippi Gulf Coast after Hurricane Katrina," unpublished paper, University of Southern Mississippi.

Sharpe, S. (1994) "Financial Market Imperfections, Firm Leverage, and the Cyclicality of Employment," *American Economic Review*, 84(4), 1060–74.

Small Business Administration (2008) "Annual Performance Report," Discussion Paper GAO-041-076, SBA.

Smith, J. P. (2012) *Hurricane Katrina: The Mississippi Story*. University Press of Mississippi, Jackson, MS.

Strobl, E. (2011) "The Economic Growth Impact of Hurricanes: Evidence from U.S. Coastal Counties," *Review of Economcis and Statistics*, 93(2), 575–589.

Stutz, H. (2006) "Harrah's Will Step Back into Biloxi this Summer," *Las Vegas Review-Journal*, March 22.

Syverson, C. (2011) "What Determines Productivity?," *Journal of Economic Literature*, 49(2), 326–365.

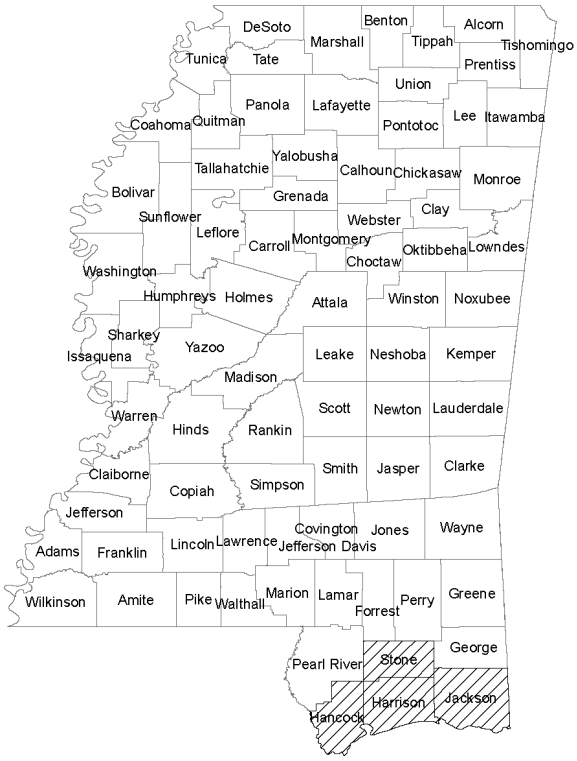

Figure 1. Mississippi (Shaded Counties Most Affected by Katrina)

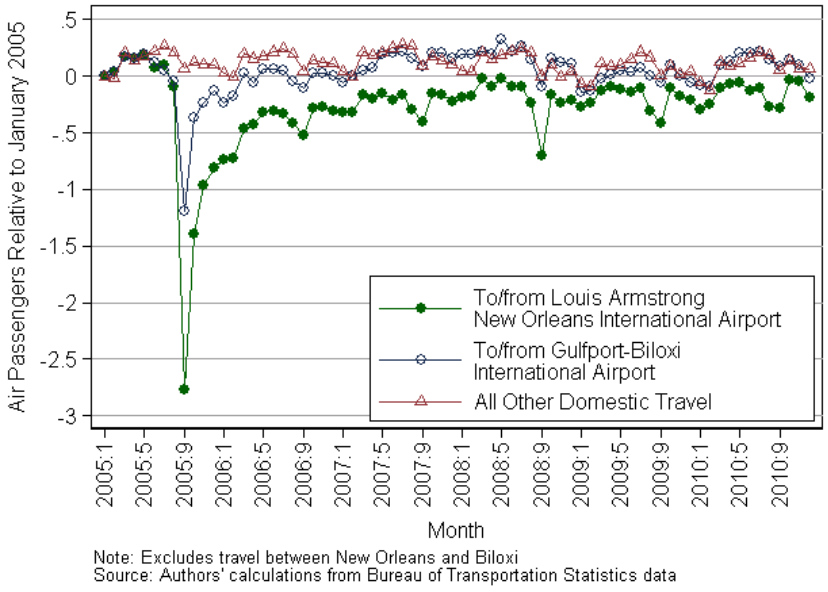

Figure 2. Air Passenger Travel to and from New Orleans and Biloxi, 2005–2010

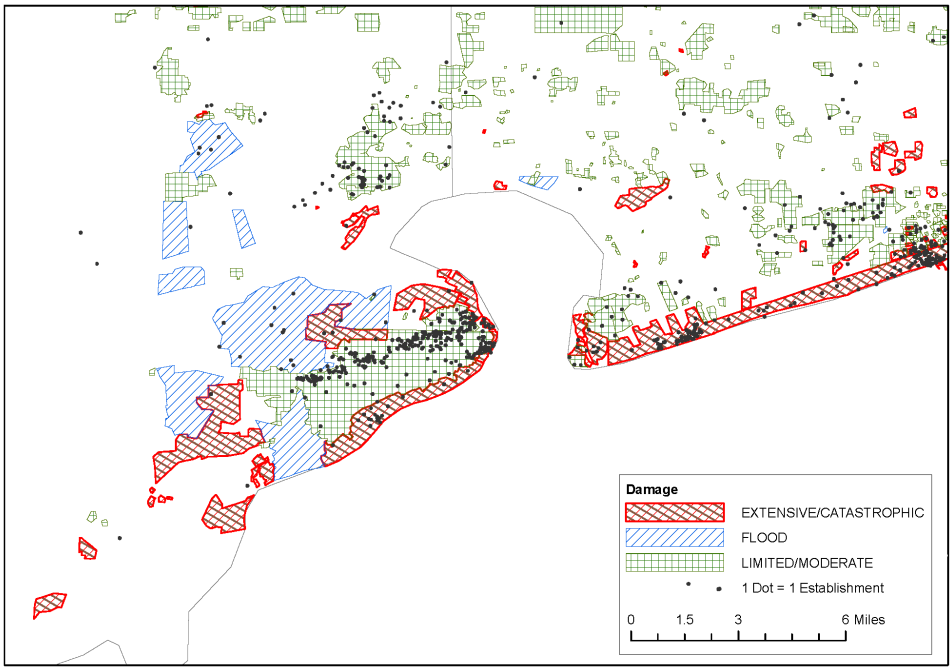

Figure 3. Damage Area Closeup: Harrison and Hancock Counties, MS

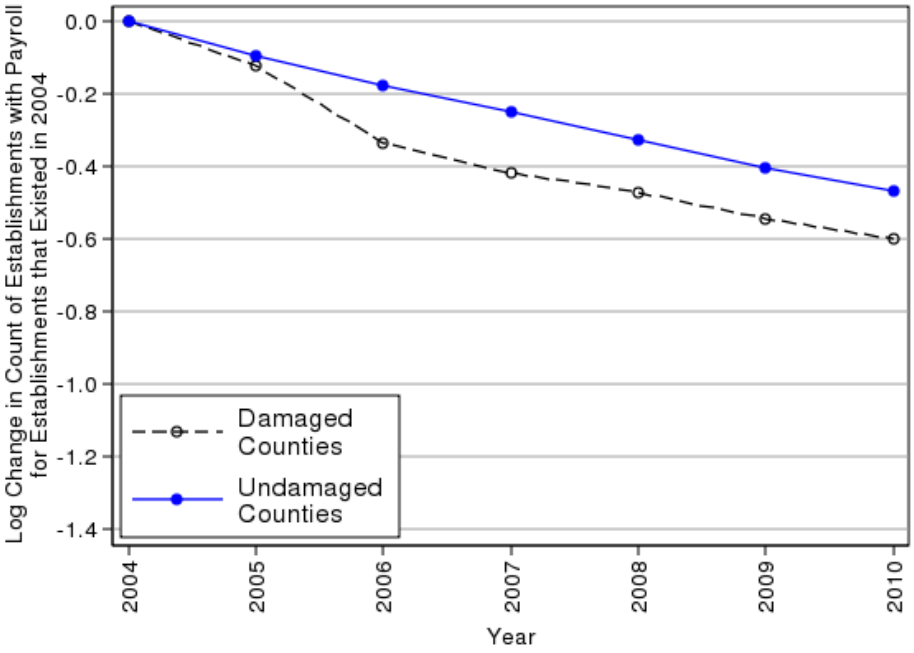

Figure 4. Log Change, since 2004, in Stores, Restaurants, and Hotels that Existed in 2004 in Mississippi

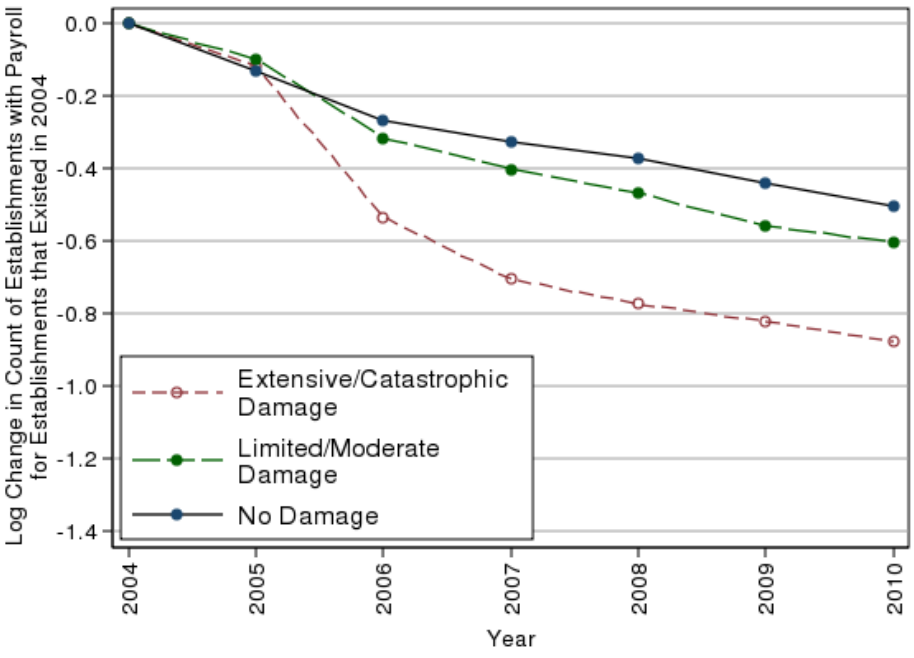

Figure 5. Log Change, since 2004, in Stores, Restaurants, and Hotels that Existed in 2004 in Damaged Counties

Table 1. Population of Selected Mississippi Counties 2000–2010

County	2000 Population	2010 Population	Log Change
Hancock	42,967	43,929	+ 2.2%
Harrison	189,601	187,105	− 1.3%
Jackson	131,420	139,668	+ 6.1%
Stone	13,622	17,786	+26.7%
Rest of State	2,467,048	2,578,809	+ 4.4%

Source: Authors' Calculations from Population Census, 2000 and 2010

Table 2. Establishment Summary Statistics: All Establishments, 2004

Variable	Estabs	All	Non-Geocoded	Geo-coded	T-test[a]
Single-unit firms (%)	16,459	64.7	60.3	65.7	0.00
Establishments in firm	16,459	423.1	463.1	413.4	0.53
Firm age	16,448	15.1	15.8	14.9	0.00
Establishment employment	16,459	15.1	14.7	15.1	0.74
Establishment age	16,459	9.9	9.5	10.0	0.10

[a] p-value from t-test for equality of means

Table 3. County Summary Statistics, 2004

State	County	Estabs	Geo-Coded	Extensive or Catastrophic	Limited or Moderate
MS	Hancock	227	208	11.5%	62.0%
MS	Harrison	1,297	1,126	34.7%	18.7%
MS	Jackson	665	578	6.1%	18.3%
MS	Stone	85	69		
MS	Rest of State	14,185	11,265		0.3%
Total		16,459	13,246	3.4%	3.6%

Damage counts are percentages of geo-coded establishments.
Blank cells indicate a cell was suppressed to comply with confidentiality standards.

Table 4. Establishment Summary Statistics: Geocoded Establishments, 2004

Variable	Estabs	All	Undamaged	Damaged	T-test[a]
Single-unit firms (%)	13,397	65.9	65.9	66.1	0.897
Establishments in firm	13,397	408.3	405.6	445.9	0.361
Firm age	13,397	14.9	14.9	14.6	0.338
Establishment employment	13,397	15.2	15.2	15.8	0.760
Establishment age	13,397	10.0	10.0	10.0	0.939

[a] p-value from t-test for equality of means

Table 5. Establishment Summary Statistics: Sole Proprietorships, 2004

Variable	Estabs	All	Undamaged	Damaged	T-test[a]
Female owner	1,887	0.3	0.3	0.4	0.910
Firm employment	1,887	3.8	3.8	4.0	0.715
Firm age	1,887	9.9	9.9	10.1	0.867
Establishment employment	1,887	3.8	3.8	4.0	0.585
Establishment age	1,887	9.1	9.1	9.2	0.890

[a] p-value from t-test for equality of means

Table 6. Difference-in-Difference Exit Regressions: Firm Age and Damage

	2002–04	2004–06	2006–08	2008–10
Extensive/Catastrophic	-0.0032	0.2538***	-0.0054	-0.1573**
Damage	(0.0165)	(0.0591)	(0.0324)	(0.0773)
Limited/Moderate	0.0657**	-0.0249	-0.0283	-0.0108
Damage	(0.0310)	(0.0980)	(0.1081)	(0.0573)
ln(Firm Age)	-0.0542***	-0.0559***	-0.0657***	-0.0763***
	(0.0046)	(0.0040)	(0.0046)	(0.0059)
$\mathbb{I}$(Firm Age = 0)[a]	0.0013	-0.0199		
	(0.0161)	(0.0205)		
Extensive/Catastrophic	-0.0013	-0.0369***	0.0428***	0.0530*
$\times$ ln(Age)	(0.0079)	(0.0121)	(0.0108)	(0.0287)
Limited/Moderate	-0.0176	0.0040	0.0175	0.0097
$\times$ ln(Age)	(0.0158)	(0.0328)	(0.0351)	(0.0152)
Extensive/Catastrophic	0.0558	0.0124		
$\times\mathbb{I}$(Age = 0)	(0.0407)	(0.0673)		
Limited/Moderate	-0.1931***	0.0375		
$\times\mathbb{I}$(Age = 0)	(0.0422)	(0.1568)		
County FE	✓	✓	✓	✓
NAICS FE (6 digit)	✓	✓	✓	✓
Observations	12,666	13,397	10,995	9,461
Percent predicted outside $[0, 1]$	<1%	1%	1%	<1%

Robust standard errors in parentheses, clustered by county.
* significant at 10%; ** significant at 5%; *** significant at 1%
[a] Age of zero occurs only in 2002 and 2004 samples; 2006 and 2008 samples are continuers from 2004

Table 7. Difference-in-Difference Exit Regressions: Firm Size and Damage

	2002–04	2004–06	2006–08	2008–10
Extensive/Catastrophic	-0.0091	0.2112***	0.0948***	-0.0312***
Damage	(0.0060)	(0.0420)	(0.0239)	(0.0083)
Limited/Moderate	0.0009	-0.0084	-0.0035	0.0124
Damage	(0.0122)	(0.0407)	(0.0236)	(0.0294)
ln(Firm Size)	-0.0207***	-0.0192***	-0.0169***	-0.0142***
	(0.0011)	(0.0012)	(0.0017)	(0.0012)
Extensive/Catastrophic	0.0014	-0.0218***	0.0051***	0.0087***
$\times$ ln(Size)	(0.0014)	(0.0021)	(0.0018)	(0.0027)
Limited/Moderate	0.0008	-0.0060	0.0093***	0.0006
$\times$ ln(Size)	(0.0036)	(0.0064)	(0.0035)	(0.0050)
County FE	✓	✓	✓	✓
NAICS FE (6 digit)	✓	✓	✓	✓
Observations	12,666	13,397	10,995	9,461
Percent predicted outside $[0, 1]$	5%	3%	4%	2%

Robust standard errors in parentheses, clustered by county.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 8. Difference-in-Difference Exit Regressions: Owner Gender

	2004–06	2006–08	2008–10
Extensive/Catastrophic	0.1699***	0.2784***	0.0634
Damage	(0.0402)	(0.0336)	(0.0621)
Limited/Moderate	0.0229	-0.1648***	0.1421
Damage	(0.1202)	(0.0324)	(0.1179)
Female-Owned	0.0224	0.0654***	0.0317
Business	(0.0257)	(0.0240)	(0.0250)
Extensive/Catastrophic	0.2038**	0.0326	-0.0677
$\times$Female-Owned	(0.0944)	(0.0829)	(0.1787)
Limited/Moderate	-0.0054	0.0093	-0.1252
$\times$Female-Owned	(0.0698)	(0.0413)	(0.1065)
NAICS FE (6 digit)	✓	✓	✓
Observations	1,887	1,366	1,090
Percent predicted outside $[0, 1]$	1%	2%	4%

Robust standard errors in parentheses, clustered by county.
* significant at 10%; ** significant at 5%; *** significant at 1%

A Appendix Figures and Tables

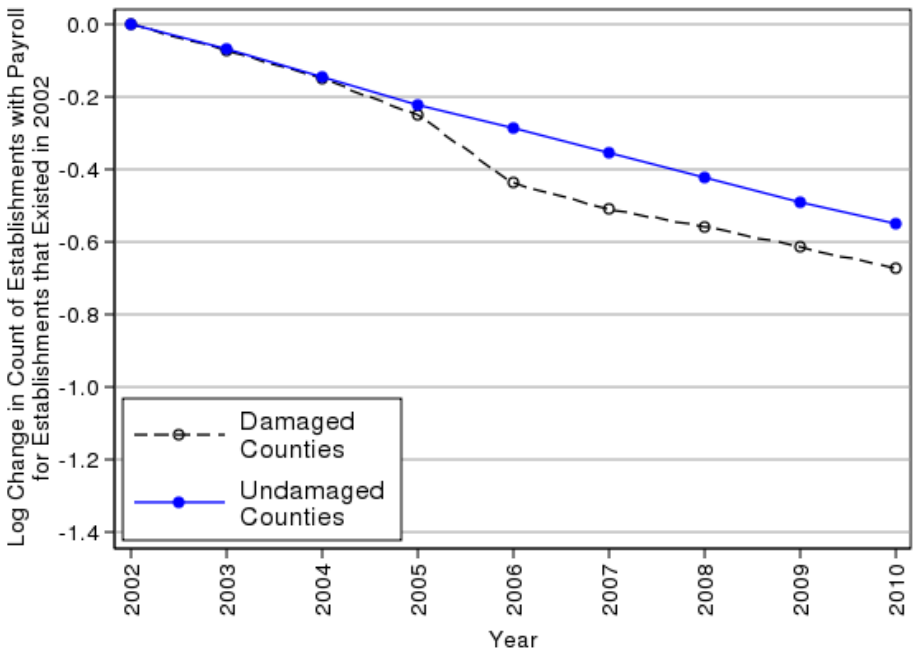

Figure A-1. Log Change, since 2002, in Stores, Restaurants, and Hotels that Existed in 2002 in Mississippi

Table A-1. Establishment Summary Statistics: All Establishments, 2002

Variable	Estabs	All	Non-Geocoded	Geo-coded	T-test[a]
Single-unit firms (%)	16,353	64.4	59.8	65.7	0.00
Establishments in firm	16,353	381.6	398.7	376.6	0.30
Firm age	16,256	14.4	14.8	14.3	0.12
Establishment employment	16,352	14.6	12.8	15.1	0.54
Establishment age	16,353	9.6	9.1	9.7	0.00

[a] p-value from t-test for equality of means

Table A-2. Establishment Summary Statistics: Geocoded Establishments, 2002

Variable	Estabs	All	Undamaged	Damaged	T-test[a]
Single-unit firms (%)	12,666	65.8	65.8	65.3	0.739
Establishments in firm	12,666	377.2	371.6	455.2	0.410
Firm age	12,666	14.2	14.3	14.0	0.535
Establishment employment	12,666	15.1	15.0	16.6	0.448
Establishment age	12,666	9.7	9.7	9.7	0.985

[a] p-value from t-test for equality of means